CHAPTER 2

DISPOSAL OF RADIOACTIVE WASTE IN BELARUS AND COMPLICATIONS FROM THE CHERNOBYL DISASTER

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2.1 INTRODUCTION

A very large area of the Republic of Belarus was exposed to radioactive contamination as a result of the accident at the Chernobyl nuclear power plant on April 26, 1986. Following the accident, the reactor which contained 190.2 t of nuclear fuel, released 1.85 x 10^{18} Bq of radiation into the environment, of which approximately 70% fell within the territory of Belarus. The released composition included a large amount of radionuclides of iodine, cesium, cerium, barium, strontium, plutonium, etc.

As shown in Figure 2.1, the prevailing winds carried contamination as much as 300 km away from the plant to the north and to the west in Belarus. Atotal of 46,450 km^2 (23% of the country) was contaminated, an area that was originally inhabited by 2.1 million people (over 20% of the population). The contamination has affected 1.8 million hectares of agricultural lands, of which 264,000 hectares have been excluded from use. The territory of the Polessie State Radioecological Reserve (131,400 hectares) has been turned into a "plutonium reservation" and is practically excluded from use because of the high levels of contamination.

Although Belarus has no nuclear power plant producing spent fuel, it has some very serious problems in developing appropriate remediation measures to collect and isolate the many kinds of contamination that are spread throughout the affected areas (Fig. 2.1).

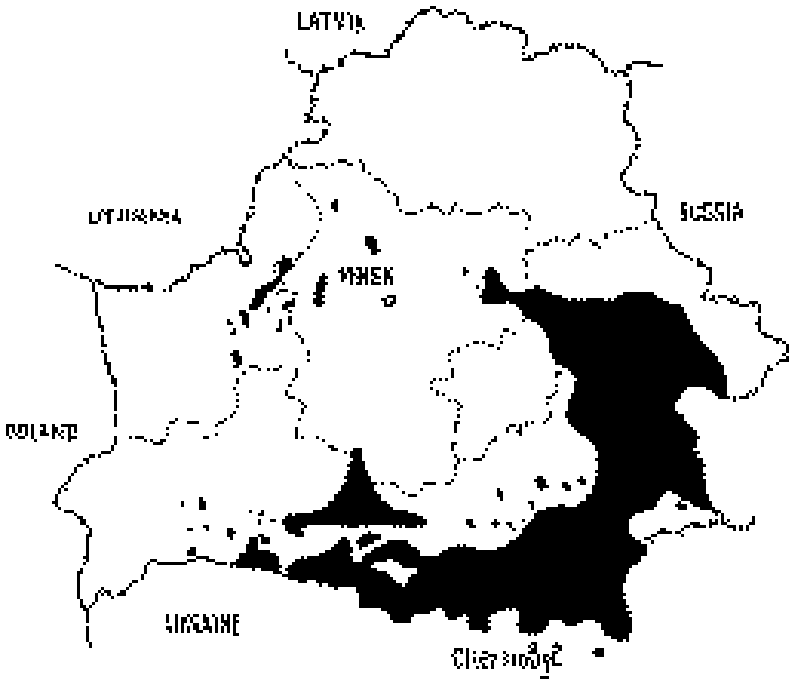

Figure 2.1. Areas in the Republic of Belarus contaminated by radionuclides from Chernobyl.

2.2 DECONTAMINATION WASTE AND BURIAL METHODS

The Belarus territory has received a great amount of radionuclide fallout over a significant percentage of its arable land, and although the contaminated industrial and other objects are numerous and widespread, the activity of the decontamination products (DP) is rather low, of the order of 10^{-6} to 10^{-8} Ci/kg. In view of the specific character of the releases from Chernobyl and considering the DP and its associated materials as one category of radioactive waste, the National Committee for Radioactivity Protection (NCRP) of Belarus has adopted the levels of specific activity as shown in Table 2.1.

Table 2.1. Specific activities of radionuclides.

Radionuclide	Specific Activity Bq/kg
Cesium-137	$8.5x10^3$
Strontium-90	$3.7x10^4$
Other beta-emitters	$7.4x10^4$
Plutonium and other transuranic elements	$3.7x10^2$

An effective program of decontamination outside the 30-km zone (plutonium contamination zone around Chernobyl) was carried out in the period 1986-1988. As a result, 12 million m^2 of exterior surfaces of buildings and other constructions were cleaned, 13.3 million m^3 of contaminated ground were removed and buried, and 7570 old buildings were demolished and buried. These DP were stored far from populated areas, mainly in unprepared sites (such as flat areas, gullies, sinks, old quarries, etc.). About 980,000 m^3 of DP and other contaminated refuse are located in 69 partially equipped repositories and five makeshift burial grounds. All these sites are constructed in zones where the ^{137}Cs activity of the soils is 15 Ci/km^2 and above; the gamma radiation exposure dose rates in the storage sites vary from 0.03 to 0.23 mR/h. The cumulative activities total 1.9 TBq for ^{137}Cs, 0.14 TBq for ^{90}Sr, and 2.6 TBq for $^{239,240}Pu$.

Most of these burials are ecologically unsuitable, and the radioactive wastes placed there need to be reburied. A concept and strategy for reburial have been developed, and sites with a suitable geology and geomorphology for constructing repositories have been selected. When selecting sites for DP repositories, the following factors have been considered:

- Location of testing grounds in evacuation zones and obligatory evacuation of people from areas where the activity exceeds 40 Ci/km^2;
- Correspondence of the geologic and hydrogeologic conditions of the locality to the requirements for safe radioactive waste isolation;
- Hydrogeologic conditions of the territory with reference to flooding and seasonal water levels, areas subjected to flooding, etc.;
- Structure of atmospheric circulation and seasonal wind patterns in relatively uncontaminated areas and populated areas; and
- DP transportation routes, quality of major and secondary highway routes (near cities), dust generation during loading, transportation, etc.

Amodel to forecast the migration of radionuclides away from waste repositories has been developed for recommended objects with given migration parameters.

2.3 PROGRAMME FOR DEEP DISPOSAL OF RADIOACTIVE WASTE

In the context of the government programme to construct nuclear power plants in the future, sites for their location have been selected, and a preliminary investigation of geological conditions has been carried out to locate potential sites for repositories for high- and medium-level radioactive wastes. Three rock types have been recognized as potentially being able to provide satisfactory conditions for radioactive waste disposal: (a) the crystalline basement, (b) salt beds, and (c) thick deposits of monomineral clays.

As shown on Figure 2.2, the territory of Belarus has been subdivided into zones showing various conditions to be considered in selecting sites:

- Areas marked Zone I are where the depth to basement ranges from 0.0 to 0.4 km and where conditions are considered very promising for engineering and constructing repositories in basement crystalline rocks;
- Areas marked Zone II are where the depth to basement ranges from 0.4 to 0.6 km and where conditions do not show much promise for repositories in basement crystalline rocks;
- Areas marked Zone III are where the depth to basement ranges from 0.6 to 1.5 km and where conditions

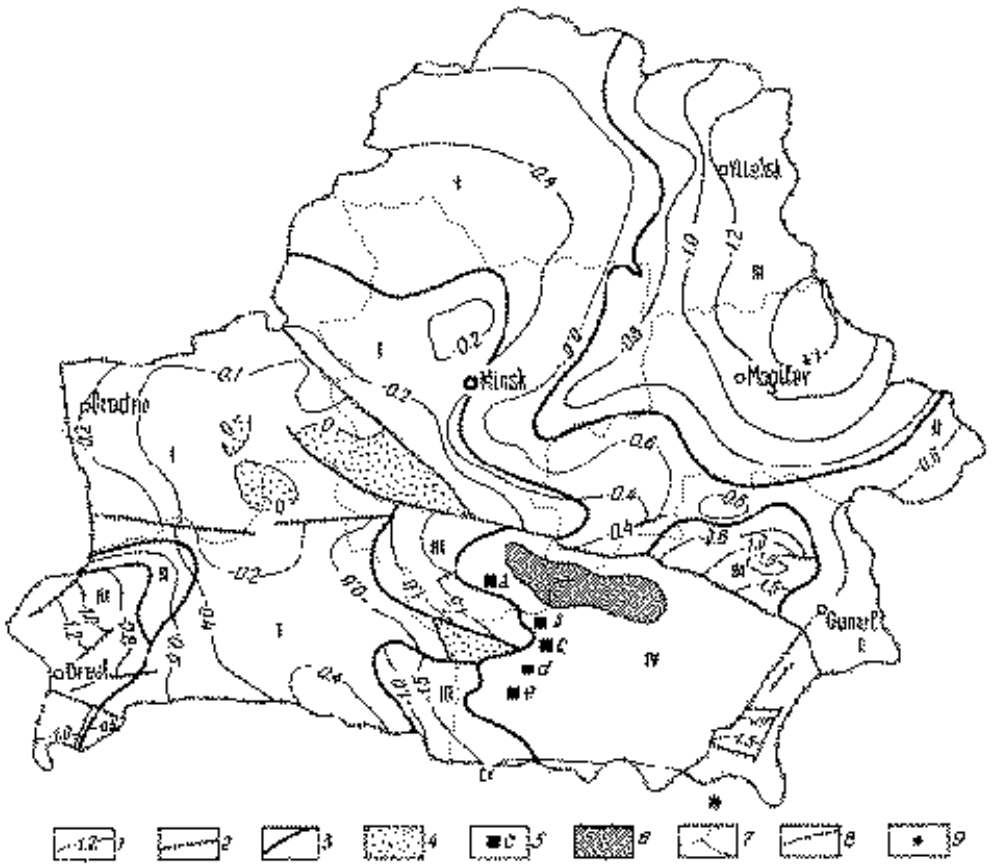

Figure 2.2. Geological division of Belarus into zones in accordance with conditions for medium- and high-level radioactive waste isolation. Legend: 1 - isolines showing depth to crystalline basement (km); 2 - tectonic faults penetrating through the sedimentary cover; 3 - boundaries of zones with different conditions and potential for waste isolation. Symbols for regions with geologic structures considered as primary candidates for repositories: 4 - crystalline basement of Bobovnya, Slonin and Mikashevichy uplifts; 5 - salt diapir domes of: a - Novaya Dubrova, b - Zarechie, c - Kopatkevichy, d - Konkovichy, e - Shestovichy; and 6 - palygorskite clay beds of Pripyat Graben. Other symbols: 7 - boundaries of districts; 8 - frontier of Belarus; and 9 - Chernobyl nuclear power plant.

show very little promise for radioactive waste repositories; and

- The area marked Zone IV is the Pripyat Graben that is considered to have highly promising geological structures for waste repositories in: (a) stratified saliferous formations of Middle and Upper Devonian, (b) domed salt diapirs of the Upper Salt strata, as well as in (c) palygorskite clay beds of Upper Devonian strata.

Crystalline rocks are exposed or overlain by Anthropogene deposits of limited thickness within the Central-Belarussian massif, Ukrainian shield and Mikashevichy uplift (horst). The Central-Belarussian massif with the Bobovnya uplift of granitic rocks (100-170 m in thickness) and the Slonim uplift of granulitic complexes with blastomilonite show the greatest promise for a site for radioactive waste isolation.

Salt formations cover a vast area (23,000 km^2) within the Pripyat Graben and are represented by two Upper-Devonian salt strata: (a) Upper Frasian (up to 1100 m thick), and (b) Upper Famennian (up to 3000 m thick zones of diaparisim) separated by terrigenous-carbonate strata. Salt formations occur in zones of diapirism in a depth range of 300 to 400 m and have the potential as sites for waste disposal (Novaya Dubrova, Zarechye and Kopatkevich uplifts on the northwest, and Konkovichy

and Shestovichy uplifts, on the southwest side of the graben).

Large deposits of palygorskite clays are found in the Pripyat Graben at depths of 80 to 120 m, and with thicknesses of as much as 140 to 150 m, they are of particular interest as potential sites for radioactive waste repositories.

Acknowledgments

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